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IN THE UNITED STATES PATENT
AND TRADEMARK OFFICE

APPLICATION FOR
UNITED STATES UTILITY PATENT

CENTRALIZER

10-ETAL INVENTORS

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BACKGROUND OF THE INVENTION

Field Of The Invention

This invention is directed to centralizers for use in wellbore operations; and, in one particular aspect to centralizers with movable spring bows, particularly such centralizers which can be used in a relatively small annular space and which can expand in a larger annular space.

Description of Related Art

Bowspring centralizers are used to center one tubular member inside a borehole or in another tubular member, e.g. to center a first smaller casing in a second larger casing. Typically centralizers are placed on the exterior of an inner casing and project outwardly therefrom. In many typical situations the annular space between the outer circumference of the smaller casing and the inner circumference of the larger casing is sufficiently large that, with some force, a centralizer on the inner first casing can be moved into the interior of the second outer casing. The centralizer will present some fluid flow restriction in the annular space.

In a variety of situations the annular space is relatively small and it is difficult or impossible to use conventional multi-spring bow centralizers or conventional rigid centralizers. Attempts have been made to fabricate an apparatus from a tubular member with vanes welded on or milled into the tubular to provide standoff of the inner casing from the outer casing, or, in another aspect, standoff of the casing from a wellbore's interior. One such device provides standoff of casing from a wellbore equal to half the difference between vane outside diameter and casing outside diameter. In some situations these apparatuses do not achieve sufficient standoff, e.g. when a wellbore is underreamed or "washed out" to a significantly larger diameter so that the vanes (or bows) have significantly reduced standoff and/or reduced contact with the wellbore interior.

The present inventors have recognized the problems mentioned above and have recognized that it would be very desirable to have a centralizer which is usable in a relatively small annular space and yet which has the ability to function in a larger annular space.

SUMMARY OF THE PRESENT INVENTION

The present invention, in one aspect, discloses a centralizer apparatus which has a body comprising a tubular member with a longitudinal bore therethrough along its length; one or more circumferential grooves formed or milled in an exterior surface of the body; a collar movably disposed in the groove or grooves; and a plurality of spring bows fixed to or movably secured to a first collar and a second collar spaced apart from the first collar.

At least one collar is longitudinally movable in its corresponding groove and has a degree of freedom of movement in the groove which permits the spring bows (which are normally naturally biased to spring away from the tubular member) to collapse toward the tubular member when forced inwardly by contact with the interior of a wellbore or of a second tubular member. In certain embodiments, the groove or grooves are of sufficient depth and the degree of movement is such that the collar and spring bows are movable to allow the spring bows to lie flat against the tubular body and, in one aspect, within recesses or grooves therein.

In certain embodiments only one movable collar is employed and the spring bows are secured either to the tubular member itself or to a collar which is also immovably or relatively immovably affixed to the tubular member. In another aspect each of a plurality of spring bows has a first end secured to the tubular member and a second end which is not fixed to the tubular member and is free to move longitudinally with respect to the tubular member. In one such embodiment one or both spring bow ends may be disposed wholly or partially in a corresponding recess in the exterior surface of the tubular member or in a slot through a portion of the tubular member. In one aspect such a groove or recess may extend on the

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tubular member along the entire length of the spring bow so that a major portion of the spring bow may repose in the recess or groove when it is collapsed toward the tubular member.

5 In certain embodiments one or both ends of a spring bow are movably held on a collar so that the spring bow end, and hence the spring bow itself, is movable with respect to the collar. The collar may be fixed to the tubular member or movable on the tubular member. Any collar described herein may be movable in a groove or recess extending around a tubular member or it may be emplaced
10 around the tubular member's exterior without the use of a groove or recess. Collars may be emplaced around a tubular body in two pieces which are then secured together, e.g. by welding and/or with connection pins or screws; or a one piece collar with a gap between its ends may be placed around a tubular body and then the ends are
15 welded together.

In certain embodiments the tubular member is a piece of casing like the other casing in a first casing string which is to be centered within a second casing string or a wellbore. In another embodiment the tubular member is a piece of tubing which is used as
20 part of a tubing string employed in a larger tubing or casing string. Such a piece of casing or tubing used as the tubular member may have threaded ends to facilitate its insertion into a casing string or tubing string and mating with other pieces of casing or tubing on either end thereof.

25 Centralizers and/or any or all parts thereof according to this invention may be made of any suitable material, including, but not limited to, metal, plastic, fiberglass, composites, cermets, aluminum, aluminum alloys, brass, copper, zinc, or zinc alloys.

In certain embodiments which have a lower movable collar, the
30 collar is movable upon contact of the spring bows, e.g. by contacting a slightly larger casing into which the centralizer apparatus is being inserted, so that the movable collar is pushed up against a stop or a top side wall of a groove in which it is disposed. Since the collar can no longer move on the tubular

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member the spring bows are pulled into the larger casing due to the downward movement of the entire centralizer apparatus. At the same time the end of the larger casing is forcing the spring bows inwardly and, if a movable upper collar is used, the movable upper collar is moving upwardly in its groove while the spring bows are moving toward and/or to contact the tubular body.

It is, therefore, an object of at least certain preferred embodiments of the present invention to provide:

New, useful, unique, efficient, nonobvious devices and methods for centralizing one tubular member in another or in a wellbore;

Another object of the present invention is to provide centralizer apparatus useful in a relatively small annular space between two tubular members or between a tubular member and a wellbore;

Another object of the present invention is the provision of such centralizer apparatus in which spring bows of the apparatus may move so that the apparatus is movable into or through a tubular member which is not much larger in inner diameter than the centralizer apparatus is in outer diameter;

Another object of the present invention is the provision of a centralizer apparatus in which lower ends of spring bows are immobile or are held immobile so that in effect the spring bows are pulled into a wellbore or into a larger tubular into which the centralizer apparatus is being inserted;

Another object of the present invention is the provision of such centralizer apparatus in which some or all of a spring bow is collapsible into a slot, groove or recess in or on the tubular member; and

Another object of the present invention is the provision of a centralizer apparatus with two spaced apart collars movably emplaced on a tubular body with a plurality of outwardly-biased spring bows extending between and secured to the collars; the collars movable in grooves or recesses on the tubular body and at least a portion of the spring bows collapsible into recesses on the

tubular body or into slots therein.

Certain embodiments of this invention are not limited to any particular individual feature disclosed here, but include combinations of them distinguished from the prior art in their structures and functions. Features of the invention have been broadly described so that the detailed descriptions that follow may be better understood, and in order that the contributions of this invention to the arts may be better appreciated. There are, of course, additional aspects of the invention described below and which may be included in the subject matter of the claims to this invention. Those skilled in the art who have the benefit of this invention, its teachings, and suggestions will appreciate that the conceptions of this disclosure may be used as a creative basis for designing other structures, methods and systems for carrying out and practicing the present invention. The claims of this invention are to be read to include any legally equivalent devices or methods which do not depart from the spirit and scope of the present invention.

The present invention recognizes and addresses the previously-mentioned problems and long-felt needs and provides a solution to those problems and a satisfactory meeting of those needs in its various possible embodiments and equivalents thereof. To one of skill in this art who has the benefits of this invention's realizations, teachings, disclosures, and suggestions, other purposes and advantages will be appreciated from the following description of preferred embodiments, given for the purpose of disclosure, when taken in conjunction with the accompanying drawings. The detail in these descriptions is not intended to thwart this patent's object to claim this invention no matter how others may later disguise it by variations in form or additions of further improvements.

DESCRIPTION OF THE DRAWINGS

A more particular description of embodiments of the invention briefly summarized above may be had by references to the

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embodiments which are shown in the drawings which form a part of this specification. These drawings illustrate certain preferred embodiments and are not to be used to improperly limit the scope of the invention which may have other equally effective or legally equivalent embodiments.

Fig. 1a is a side view, partially in cross-section, of a centralizer according to the present invention.

Fig. 1b is a cross-sectional view along line 1b-1b of Fig. 1a.

Fig. 1c is an enlargement of the detail of circle c in Fig.

10. 1b.

Fig. 1d is an enlargement of the detail of circle d in Fig. 1a.

Fig. 1e is a side view, partially in cross-section, of the centralizer of Fig. 1a.

15 Fig. 2 is a side cross-section view of a tubular body of the centralizer of Fig. 1a.

Fig. 3a is an end view of a spring bow.

Fig. 3b is a side view of the spring bow of Fig. 3a.

20 Fig. 4 is a side view, partially in cross-section, of a centralizer according to the present invention.

Fig. 5 is a side view, partially in cross-section, of a centralizer according to the present invention.

Fig. 6 is a side view, partially in cross-section, of a centralizer according to the present invention.

25 Fig. 7 is a side view, partially in cross-section, of a centralizer according to the present invention. Fig. 7b is a partial cross-section view along line 7b-7b of Fig. 7a.

Fig. 8 is a side view, partially in cross-section, of a centralizer according to the present invention.

30 Fig. 9a is an end view of a centralizer according to the present invention. Fig. 9b is a partial side view of the centralizer of Fig. 9a.

Fig. 10a is a partial side view of a centralizer according to the present invention. Fig. 10b is a partial side view of the

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centralizer of Fig. 10a.

Fig. 11 is a side view of a centralizer according to the present invention.

Fig. 12 is a side view in cross-section of a tubular body for
5 a centralizer according to the present invention.

**DESCRIPTION OF EMBODIMENTS PREFERRED
AT THE TIME OF FILING FOR THIS PATENT**

10 A centralizer 10 according to the present invention as shown in Fig. 1a has a tubular body 12 with a central longitudinal bore 14 running therethrough. In certain aspects the tubular body 12 is a piece of casing or tubing. Formed in or machined into an exterior surface 16 of the tubular body 12 are two collar grooves 18 and a spring bow groove 22.

15 A first collar 24 is movably disposed in the top collar groove 18 and a second collar 26 is movably disposed in the bottom collar groove 18. A plurality of spring bows 20 are spaced apart around the collars 24, 26 with opposing ends secured to each collar. Preferably each spring bow end (like the spring bow end 28, Fig.
20 1c) is disposed in a groove 32 in one of the collars so that all or substantially all of the spring bow ends do not extend beyond an outer surface 34 of the collars.

As shown in Fig. 1e, the two collars 24, 26 have moved apart from each other in their respective collar grooves 18; and the
25 spring bows 20 have collapsed with a major portion thereof in the groove 22. A bottom ridge 23 provides a stop which abuts the lower collar 26 when it has moved in response to spring bow contact with another member, e.g. a slightly larger casing. Once such abutment occurs, the spring bows are pulled into the larger casing as the
30 centralizer is moved downwardly into the larger casing.

Fig. 3b shows a spring bow 50 with a body 52 and ends 54, 56. Fig. 3a shows the end 54 (like the end 56) which has a curved shape to accommodate the curved exterior surface 16 of the tubular body 12. The curved shape also permits the ends 54, 56 to "hug" the



exterior surface 16 reducing the extent to which the ends would project beyond the surface 16. The spring bows 20 may have non-curved ends or they may be like the spring bow 50.

Fig. 4 illustrates a centralizer 60 according to the present invention which is like the centralizer 10 (with like numerals indicating similar parts); but the centralizer 60 has only one collar groove 18 and only one movable collar 24. The lower collar 26 may be in a groove 27 in which it does not move or it may be fixed around a tubular body 13 of the centralizer 60. The tubular body 13 (like the tubular body 12) has a bore 15 (like the bore 14) therethrough. Upon movement of the collar 24, the spring bows 20 can move toward and collapse against an exterior surface of the tubular body 13.

Fig. 5 illustrates a centralizer 70 according to the present invention (in which parts similar to those of centralizer 10 bear the same identifying numerals) with one movable collar 24 movable in a collar groove 18. Ends 21 of spring bows 23 (like the spring bows 20) are secured to a tubular body 17 of the centralizer 70, e.g. by welding. Upon movement of the collar 24, the spring bows 23 can move toward and collapse against an exterior surface of the tubular body 17. A groove or recess 29 may be provided to receive the spring bows when they collapse.

Fig. 6 illustrates a centralizer 80 according to the present invention. A plurality of spring bows 81 have a first end 82 secured to a tubular body 83 of the centralizer 80. A second end 84 of each spring bow 81 is receivable in and movable in a groove 85 formed in or milled in the tubular body 83. A bore 86 extends through the body 83. Upon contact of the spring bows 81 with an interior of another tubular or a wellbore, the spring bows move toward the tubular body 83 with their ends 84 moving in the grooves 85 so that the spring bows collapse against the tubular body 83.

Figs. 7a and 7b illustrate a centralizer 90 according to the present invention which has a tubular body 91 with a bore 92 therethrough. A plurality of spring bows 93 each has an end 94

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secured to the tubular body 91 and an end 95 freely movable in a slot 96 extending through a portion of the tubular body 91. A groove or recess may be used beneath each spring bow to receive some, a major portion of, or all of it upon collapse of the spring bows against the tubular body.

Fig. 8 shows a centralizer 40 like the centralizer 90; (and like aspects bear like identifying numerals); but the spring bows 93 have a tab end 41 which is movable in an enlarged portion 42 of a slot 43. It is within the scope of this invention to provide a tab 41 and a slot 43 for the opposing spring bow ends. Such a tab end and enlarged groove portion may be used with the ends 84 of the spring bows 81 in the centralizer 80 of Fig. 6. In one aspect the tab end may be a piece which is initially separate from the spring bow, but which is secured to a spring bow end (e.g. by welding, screws, or bolts) once the spring bow end is inserted into and through a slot.

It is within the scope of this invention to provide structures which project beyond the exterior surface of a centralizer body and confine a spring bow end with the spring bow end movable in the structure so that the spring bow can collapse. Alternatively such a structure may be provided on a collar that is fixed (movably or immovably) around a centralizer body or around a groove in a centralizer body. Figs. 9a and 9b show a centralizer 100 according to the present invention with a tubular hollow body 101 and one or more spring bow end retainers 102 and a spring bow 103. Any number of spring bow retainers 102 and spring bows 103 may be used spaced apart around the outer circumference of the tubular hollow body 101. The retainer 102 has two upright arms 104, each with a shoulder 105, and with a gap 106 between them. A lower portion 107 of the spring bow 103 is movably confined beneath the shoulders 105 and an upwardly extending portion 108 moves in the gap 106. An end 109 of the spring bow is larger than a space 110 between two stop members 111, thus preventing the spring bow from falling off of the tubular body 101.

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Figs. 10a and 10b show a centralizer 120 with a tubular body 121 and one (or more) spring bows 122. An end 123 of the spring bow 122 is movably disposed under a bar 124 which holds the spring bow end and prevents it from falling away from the tubular body 121. An arch 125 in the spring bow end moves over a stop member 126, e.g. when the spring bow moves inwardly to collapse against the tubular body 121. In preferred embodiment the various parts, grooves, recesses, etc. are sized, disposed and configured to permit full collapse of the spring bow(s) against and/or into the tubular body (as with all embodiments described and claimed herein). The spring bow end moves in a recess 129. The spring bows of the apparatuses of Figs. 9a and 10a may have tab ends like those of the apparatus of Fig. 8.

Fig. 11 shows a centralizer 130 with a hollow tubular body 131. A top end groove 132 and a bottom end groove 133 are formed of or milled or machined into an outer surface 134 of the hollow tubular body 131. The end grooves are sized and configured to permit ends 135 and 136 of a spring bow 140 to move therein so that a body 141 of the spring body 140 may move into a longitudinal groove 137 in the outer surface 134 when the spring bow 140 collapses toward the hollow tubular body 131. Retainers 145 (like the retainers 102, Fig. 9a) hold tab ends 146 of the spring bow 140 as they move within the retainers 145.

Fig. 12 illustrates a tubular body 29 (like the tubular body 12, Fig. 2); but which has only one large groove 55 therearound for accommodating two movable collars (like, e.g., collars 24, 26, Fig. 1a) and the spring bows. In any embodiment of this invention the tubular body may be solid or it may have a fluid flow bore or bores therethrough.

In certain embodiments of the present invention it is preferred that the parts, grooves, and recesses are sized, configured, and disposed so that the collars and spring bows, upon collapse of the spring bows against the apparatuses tubular body, do not project beyond the tubular body's exterior surface more than

three-eighths of an inch. In other embodiments this preferred length is no more than one-fourth inch; one-eighth inch; one-sixteenth inch; or zero. In other embodiments the collars and spring bows are within grooves, recesses, etc. and are below the top level of the tubular body's exterior surface.

In conclusion, therefore, it is seen that the present invention and the embodiments disclosed herein and those covered by the appended claims are well adapted to carry out the objectives and obtain the ends set forth. Certain changes can be made in the subject matter without departing from the spirit and the scope of this invention. It is realized that changes are possible within the scope of this invention and it is further intended that each element or step recited in any of the following claims is to be understood as referring to all equivalent elements or steps. The following claims are intended to cover the invention as broadly as legally possible in whatever form it may be utilized. The invention claimed herein is new and novel in accordance with 35 U.S.C. § 102 and satisfies the conditions for patentability in § 102. The invention claimed herein is not obvious in accordance with 35 U.S.C. § 103 and satisfies the conditions for patentability in § 103. This specification and the claims that follow are in accordance with all of the requirements of 35 U.S.C. § 112.

What is claimed is: